

WHAT IS CLAIMED IS:

1 1. A method for forming an aperture plate, the method comprising:
2 providing a mandrel comprising a plate body having a conductive surface
3 and a plurality of non-conductive islands disposed on the conductive surface, wherein the
4 islands extend above the conductive surface and are sloped relative to the conductive
5 surface;

6 placing the mandrel within a solution containing a material that is to be
7 deposited onto the mandrel;

8 applying electrical current to the mandrel to form an aperture plate on the
9 mandrel, wherein the apertures have an exit angle that is in the range from about 30° to
10 about 60°.

1 2. A method as in claim 1, wherein the islands have a geometry that
2 approaches a generally conical shape, and wherein the islands have a base diameter in the
3 range from about 20 microns to about 200 microns and a height in the range from about 4
4 microns to about 20 microns.

1 3. A method as in claim 1, wherein the islands have an average slope
2 in the range from about 15° to about 30° relative to the conductive surface.

1 4. A method as in claim 3, further comprising forming the islands
2 from a photoresist material using a photolithography process.

1 5. A method as in claim 4, further comprising treating the islands
2 following the photolithography process to alter the shape of the islands.

1 6. A method as in claim 1, further comprising removing the deposited
2 aperture plate from the mandrel and forming a dome shape in the aperture plate.

1 7. A method as in claim 1, wherein the material in the solution is
2 selected from a group of materials consisting of palladium, palladium nickel, and
3 palladium alloys.

1 8. A method as in claim 1, wherein the apertures have an exit angle
2 that is in the range from about 41° to about 49°.

1 9. An aperture plate formed according to the process of claim 1.

1 10. An aperture plate comprising:
2 a plate body having a top surface, a bottom surface, and a plurality of
3 apertures extending from the top surface to the bottom surface, wherein the apertures are
4 tapered in a direction from the top surface to the bottom surface, and wherein the
5 apertures have an exit angle that is in the range from about 30° to about 60°, and a
6 diameter that is in the range from about 1 micron to about 10 microns at the narrowest
7 portion of the taper.

1 11. An aperture plate as in claim 10, wherein the plate body is
2 constructed from materials selected from a group consisting of palladium, palladium
3 nickel and palladium alloys.

1 12. An aperture plate as in claim 10, wherein the plate body includes a
2 portion that is dome shaped in geometry.

1 13. An aperture plate as in claim 10, wherein the plate body has a
2 thickness in the range from about 20 microns to about 70 microns.

1 14. An aperture plate as in claim 10, wherein the apertures have an exit
2 angle that is in the range from about 41° to about 49°.

1 15. A mandrel for forming an aperture plate, the mandrel comprising:
2 a mandrel body having a conductive, generally flat top surface and a
3 plurality of non-conductive islands disposed on the conductive surface, wherein the
4 islands extend above the conductive surface and have a geometry approaching a generally
5 conical shape.

1 16. A mandrel as in claim 15, wherein the islands have a base diameter
2 in the range from about 20 microns to about 200 microns, a height in the range from
3 about 4 microns to about 20 microns.

1 17. A mandrel as in claim 15, wherein the islands are formed from a
2 photoresist material using a photolithography process.

1 18. A method as in claim 17, wherein the islands are treated following
2 the photolithography process to alter the shape of the islands.

1 19. A method for producing a mandrel that is adapted to form an
2 aperture plate, the method comprising:
3 a) providing an electroforming mandrel body;
4 b) applying a photoresist film to the mandrel body;
5 c) placing a mask having a pattern of circular regions over the photoresist
6 film;
7 d) developing the photoresist film to form an arrangement of non-
8 conductive islands corresponding to the location of the holes in the pattern; and
9 e) heating the mandrel body to permit the islands to melt and flow into a
10 desired shape.

1 20. A method as in claim 19, further comprising repeating steps b)
2 through e) where the pattern of circular regions of the mask are smaller.

1 21. A method as in claim 20, wherein the desired shape is generally
2 conical.

1 22. A method as in claim 20, further comprising permitting the islands
2 to cure before repeating the steps.

1 23. A method as in claim 20, further comprising heating the mandrel
2 body until the islands have an average angle of taper that is in the range from about 15° to
3 about 30°.

1 24. A method as in claim 19, wherein the photoresist film has a
2 thickness in the range from about 4 microns to about 15 microns.

1 25. A method as in claim 19, wherein the mandrel body is heated to a
2 temperature in the range from about 50°C to about 250° C for about 30 minutes.

1 26. A method as in claim 25, further comprising raising the
2 temperature at a rate that is less than about 3°C per minute until reaching the desired
3 range.

1 27. A method for aerosolizing a liquid, the method comprising:

2 providing an aperture plate comprising a plate body having a top surface, a
3 bottom surface, and a plurality of apertures that taper in a direction from the top surface
4 to the bottom surface, wherein the apertures have an exit angle that is in the range from
5 about 30° to about 60°, and a diameter that is in the range from about 1 micron to about
6 10 microns at the narrowest portion of the taper;

7 supplying a liquid to the bottom surface of the aperture plate; and
8 vibrating the aperture plate to eject liquid droplets from the top surface.

1 28. A method as in claim 27, wherein the droplets have a size in the
2 range from about 2 microns to about 10 microns.

1 29. A method as in claim 27, further comprising holding the supplied
2 liquid to the bottom surface by surface tension forces until the liquid droplets are ejected
3 from the top surface.

1 30. A method as in claim 27, wherein the aperture plate has a least
2 about 1000 apertures which product droplets having a size in the range from about 2
3 microns to about 10 microns, and further comprising aerosolizing a volume of liquid in
4 the range from about 4 μ L to about 30 μ L within a time of less than about one second.
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6 31. An aperture plate comprising:
7 a plate body having a top surface, a bottom surface, and a plurality of
8 apertures extending from the top surface to the bottom surface, wherein the apertures each
9 include an upper portion and a lower portion, wherein the lower portion extends upwardly
10 from the bottom surface and is generally concave in geometry, and wherein the upper
11 portion is tapered in a direction from the top surface to the bottom surface and
12 intersections with the lower portion.

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14 32. An aperture plate as in claim 31, wherein upper portion has an angle
15 of taper that is in the range from about 30° to about 60° at the intersection with the lower
16 portion, and a diameter that is in the range from about 1 micron to about 10 microns at the
17 intersection with the lower portion.
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19 33. An aperture plate as in claim 32, wherein the lower portion has a
20 diameter at the lower surface that is in the range from about 20 microns to about 200
21 microns, a height in the range from about 4 microns to about 20 microns.

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23 34. An aperture plate as in claim 31, wherein the bottom surface is
24 adapted to receive a liquid, and wherein the plate body is vibratable to eject liquid
25 droplets from the front surface.

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27 35. A method for ejecting droplets of liquid, the method comprising:
28 providing an aperture plate comprising a plate body having a top surface, a bottom
29 surface, and a plurality of apertures that taper in a direction from the top surface to the
30 bottom surface, wherein the apertures have an exit angle that is in the range from about
31 30° to about 60°, and a diameter that is in the range from about 1 micron to about 10
32 microns at the narrowest portion of the taper; and
33 forcing liquid through the apertures to eject liquid droplets from the front surface.
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